# OPERATION & MAINTENANCE MANUAL

## Methanol Fuel Cell System

## IdaTech
## 2000


Document No: OM1

# REVISION LOG

Revisions to this manual may occur. To ensure that you have the most up-to-date information available, please log any revisions you receive in the table below.

| Revision No. | Comments | Section(s) | Date |
|---|---|---|---|
| 1 | Original Release | | Dec. 12, 1999 |
| 2 | Overall System Refinements | All | Feb. 25, 2000 |
| 3 | PMM and operations | 2,3,4,6 | June 9, 2000 |
| 4 | Overall System Refinements | All | July 7, 2000 |
| 5 | Revised Installation/Site Req. Added Appendix | 3 | Sept. 20, 2000 |
| | | | |

## Fuel Cell System Identification Numbers

| |
|---|
| Fuel Cell System No:<br><br>Entered by: |
| Fuel Processor No:<br><br>Entered by: |
| Power Management No:<br><br>Entered by: |
| Fuel Cell Stack No:<br><br>Entered by: |

# Table of Contents

# 1. INTRODUCTION

This operation manual is for alpha prototype residential fuel cell systems manufactured by IdaTech with model numbers of the following general format: S/N 503-xxx-##-##. These fuel cell systems are experimental prototypes and are rated to deliver about 3 kW net electrical output. Heat recovery to water is an option that is typically included with these systems.

Only properly trained personnel are to operate the fuel cell system. It is important that all instructions be followed to minimize the risk of personnel injury and/or property damage. Safety precautions are emphasized and must be followed to avoid serious injury.

One of the objectives of deploying these alpha prototype fuel cell systems is to receive feedback from participating utilities. We anticipate that problems, as well as outright failures will occur. That is the nature and purpose of an Alpha testing program, to determine the various failure modes prior to commercialization of a product. With your help and cooperation as well as the insights you will gain operating these systems daily, we will bring a thoroughly tested product to the marketplace. <u>Furthermore, when we receive a call from you concerning any system problems, IdaTech pledges to respond to you no later than the next business day.</u>

Any comments, questions, or suggestions related to the fuel cell system are strongly encouraged and should be address to:

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## *1.1. FUEL PROCESSORS*

The fuel processor is a key component of the fuel cell system (the fuel cell stack is discussed below). The fuel processor is a device that produces hydrogen from a fuel (also known as a feedstock). Another commonly used name for the fuel processor is "reformer" since the chemical reaction used to produce hydrogen is called "steam reforming".

The fuel processor in the alpha prototype residential fuel cell system has been designed, developed, and patented by IdaTech. The fuel processor produces hydrogen from the fuel (methanol) by a chemical reaction that also uses steam. The impure hydrogen stream is then purified, also within the fuel processor, and pure product hydrogen is delivered to the fuel cell stack.

The fuel processor must operate at elevated temperatures. It is heated by combustion within the device, combustion exhaust is the only material byproduct (in addition to the product hydrogen stream). **<u>The combustion exhaust must be properly vented</u>.** Please see *Installation and Site Requirements* for exhaust specifications.

Initial heating of the fuel processor is done by burning a supplemental fuel, typically propane. Once the fuel processor is hot it operates by burning waste gases produced during the generation of hydrogen. At this time the fuel processor becomes self-sustaining and no longer requires supplemental fuel. Typically, about 40 minutes is required to bring the fuel processor from its initial, ambient temperature up to operating temperature. Ambient temperature surrounding the system must be kept between 0-24°C (32-75°F) at full load.

## *1.2. FUEL CELLS*

The fuel cell stack produces electricity and heat through the reaction of hydrogen with oxygen from air. The hydrogen is derived from the fuel processor (see above). The electrical energy produced by the fuel cell stack is direct current and must be conditioned with an inverter prior to use in a standard residential application. The power management module that accompanied the fuel cell system contains the inverting power electronics.

There are several types of fuel cell stacks. The type used in these residential alpha prototype systems is a proton-exchange-membrane fuel cell (PEMFC) stack. The fuel cell stack in this system is manufactured by Nuvera, Milan, Italy.

The PEMFC is a source of considerable electrical energy. **<u>Whenever the fuel cell stack is charged with hydrogen and air, extreme caution must be exercised to avoid contact with the fuel cell, which might lead to an electrical shock by inadvertently grounding or shorting the fuel cell. This condition is possible even if the system is off.</u>**

## *1.3. SYSTEMS*

The fuel cell system, Figure 1, contains a balance-of-plant that is designed to support the operation of the fuel processor and the fuel cell stack. Specifically, the balance-of-plant includes:

1) a mechanical air supply which provides air to both the fuel processor and to the fuel cell stack;

2) a water de-ionization (DI) cartridge and filter to purify tap water for use by the fuel cell system;
3) DI water pump and domestic water pump;
4) propane tank
5) a filter on the incoming methanol supply line and a filter on the air supplied to the fuel cell stack;
6) a heat exchanger to recover heat from the fuel cell stack;
7) a radiator for removing heat from the fuel cell if heat recovery is not being used;
8) a methanol/water mix system and a 2L working reservoir to hold the methanol/water mixture;
9) a pump to supply methanol/water mixture to the fuel processor
10) control systems.

**Figure 1**

The fuel cell system produces DC electrical energy and thermal energy. The DC electrical output from the fuel cell system is converted to AC electrical energy in the Power Management Module (PMM). The PMM, shown in Figure 2, contains all the circuit breakers, disconnect switches, batteries, and all the electronics necessary to safely manage the electrical energy being produced by the fuel cell system.

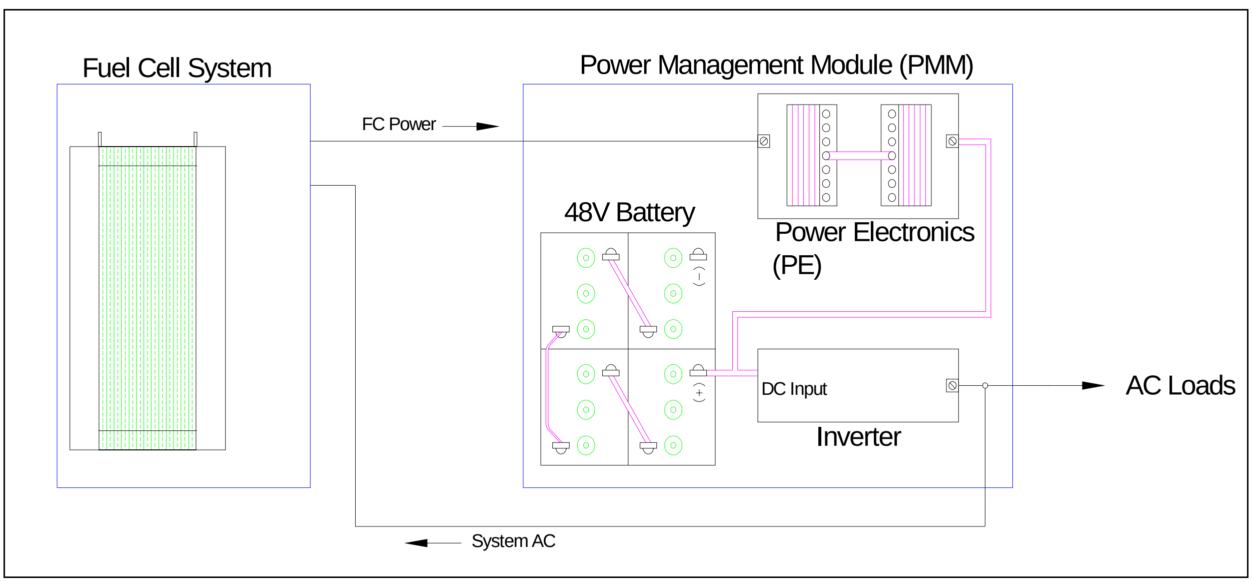



**Figure 2**

# 2. SYSTEM DESCRIPTION

## *2.1. APPLICATIONS*

People all over the world will find many applications for IdaTech fuel cell systems and novel fuel processor. Today we are just beginning to explore the commercial applications, which are of special interest to our utility partners. Through the Bonneville Power Administration (BPA) program, the testing of these alpha units will provide valuable information that will enable us at IdaTech to craft a product to meet two objectives.

1) Provide a product that meets the many needs of a utilities Distributed Resources program;
2) Furnish the end user a product that has value, is reliable, and meets a specific need.

Initial applications for our fuel cell systems include the following:

- Distributed Generation-Continuous and emergency power for utility substations, microwave and communications sites.
- Off-grid Generation-Power alternative for residences, offices, small commercial, light industrial customers, especially in areas of high power costs or sensitive environmental concerns.
- Remote Power-Primary power for rural customers where a line extension is costly or not allowed. Stranded asset costs are simply avoided with an alternative to a line extension. The federal government also requires remote power for agencies such as the U.S. Department of Fish and Wildlife, Weather Service, Forest Service and the Federal Emergency Management Agency (FEMA), many of which have service contracts already in place with the local utility.

## *2.2. FUEL CELL SYSTEM MODULE (FCSM)*

IdaTech's patented, multi-fuel capable, fuel processor is at the heart of these fuel cell systems. The system that is being furnished under the BPA program is fueled by methanol. When we couple our fuel processor with a PEM fuel cell stack, the result is a small scale power generating plant fully capable of providing electrical power and thermal energy at high efficiency to a home or office at the touch of a button. This standard system rated at 3 kW electrical can supply all the energy required in a typical 2000 square foot home located in the Pacific Northwest

## *2.3. POWER MANAGEMENT MODULE (PMM)*

The PMM is a separate enclosure from the fuel cell system. Within this enclosure is the battery bank, the Power Electronics, and inverter.

Battery Bank

The battery bank has a nominal capacity of 200Ahr. Composed of four, 12 volt, flooded-lead acid batteries connected in series to provide the system with 48 volts DC. A DC rated fuse protects the positive lead.

The batteries serve two purposes:

1) start up electrical power for the fuel cell system
2) and as noted above, instantaneous electrical power for transient or peak loads.

Power Electronics (PE)

The electrical energy from the fuel cell stack is connected to the PE through a one way link. The one way link allows energy to travel only from the fuel cell stack to the PE. The PE steps up the 24 VDC of the fuel cell to the battery voltage of 48 VDC. The output of the PE is connected to the battery and DC input of the inverter. With this common connection to the batteries and inverter, energy can be routed to the batteries to keep them charged, or energy may be used from the batteries in response to a load peaking condition which is beyond the capability of the fuel cell system. Batteries are automatically charged whenever the user load is less than the output of the fuel cell and the batteries are in need of charging (i.e., the potential of the battery bank is ≤ 45.6 VDC).

The PMM has three functions.

1) Conversion of the DC electrical energy of the fuel cell system into readily, useable AC power.
2) Provide load peaking power requirements
3) Provide AC startup power for the fuel cell system

The customer's connection point is a terminal block located inside the PE enclosure in the upper right corner. This connection is protected by two single-pole 120VAC breakers ganged together for single operation. This breaker combination may also be used as an AC system disconnect.

### *2.4. THERMAL RECOVERY SYSTEM*

The thermal or heat recovery system is designed to increase the overall efficiency of the fuel cell system. This is accomplished by using the heat generated by the fuel cell to preheat water. We do this using an internal water-to-water heat exchanger with a connection available on the back of the system enclosure. Typically, in residential applications, this would be connected to the supply side of a domestic water heater. Generally, for every kilowatt of electrical power generated by the fuel cell, there is an equal amount of thermal energy generated. This is approximately 10,000 Btu per hour of thermal power at rated load.

In most residential applications there is not a continuous need for hot water. Therefore, the heat should be stored in an auxiliary hot water tank. Over time the domestic water circulating through the fuel cell and the intermediate tank is heated up to the maximum fuel cell operating temperature of 105°F. The domestic water heater will pull water from this tank at the same time reducing heating energy that the water heater would otherwise require. A cold water line connected to the inlet of the auxiliary tank will replenish the water consumed by the domestic tank. This will lower the temperature of the water in the intermediate tank and cool the fuel cell. In the event that the auxiliary tank can no longer store heat (essentially the heat reservoir is full) there is an on-board radiator to dissipate the heat to the ambient air. If heat recovery is not utilized by the customer, then a bypass connection is used sending the fuel-cell-heated water to the on-board radiator.

### *2.5. DATA ACQUISITION SYSTEM (DAQS)*

The DAQS is a computer with monitor, located outside the Fuel Cell System Module (FCSM). It uses 1 connection to the FCSM controller to receive a continuous stream of serial data. The

DAQS can store 60 days of data for retrieval via a zip drive. The table below lists some of the data that is retrieved and evaluated by IdaTech.

Table 1-Serial Data

| **Data** | **Units** | **Range** | **Channels** |
|---|---|---|---|
| FC stack voltage | VDC | 0-60 | 1 |
| Cell potentials | mVDC | 0-1200 | 16 |
| FC stack current | ADC | 0-200 | 1 |
| Kilowatt-hours | kWh | 0-26000 | 1 |
| Fuel flow rate | ml/min | 0-60 | 1 |
| Catalyst temp | Deg. C | 0-1000 | 1 |
| Combustion temp | Deg. C | 0-1000 | 1 |
| Stack $H_2O$-temp | Deg. C | 0-100 | 1 |
| Stack air-in temp | Deg. C | 0-100 | 1 |
| Stack air-in press | psig | 0-15 | 1 |
| Reforming press | psig | 0-300 | 1 |
| $H_2$ press | psig | 0-15 | 1 |
| $H_2$ humidity | % RH | 0-100 | 1 |
| Membrane temp | Deg. C | 0-1000 | 1 |

### *2.6. EXHAUST SYSTEM*

The exhaust system combines all of the exhaust streams from the fuel processor and fuel cell subsystems. The fuel processor exhaust streams include combustion exhaust, excess hydrogen ventilation, and raffinate over-pressurization exhaust (a pressure relief valve is incorporated in the fuel processor subsystem for safety reasons.). The fuel cell exhaust streams also include cathode air exhaust and anode hydrogen. As a result of the mixing ratios of these exhaust streams the combined exhaust is not flammable. The combined exhaust stream contains $CO_2$ and water vapor, and may contain CO.

CAUTION: THE EXHAUST SYSTEM MUST BE VENTED OUTDOORS

The physical makeup of the exhaust system includes the exhaust ducting and a fan used to force exhaust out of the system. For safety, a low-pressure switch is used to detect exhaust flow during operation. The ducting connection is a 5” male crimped aluminum duct fitting. The external ducting should also have a 5” diameter and be routed upward and out of the building. Please see Section 3.7 EXHAUST GAS DUCTING for additional requirements. Other methods of ducting may also be suitable; please contact IdaTech for assistance in engineering an alternative method.

# 3. INSTALLATION AND SITE REQUIREMENTS

### *3.1. ENVIRONMENTAL*

The Fuel Cell System and the Power Management Module are both rated NEMA 1. This means that the enclosures are designed for indoor use only. They are NOT waterproof.

Specifications
Temperature: 1-24°C (34-75°F)

| |
|---|
| CAUTION: The Fuel Cell System and Power Management Module should be located in a dry, protected environment away from sources of high temperature and moisture. Salt water is particularly damaging and must be avoided. |

### *3.2. PHYSICAL SPECIFICATIONS*

(Refer to Footprint Diagrams in the Appendix.)

Fuel Cell System (FCSM)

| | |
|---|---|
| Weight: | Approximately 800 lb (363 kg) |
| Height: | 42.6 in (108.2 cm) increased to 66 in (167.6 cm) when access lid is opened. |
| Width: | 48.8 in (123.9 cm) |
| Depth: | 32.5 in (82.6 cm), 30.3 in (77 cm) with front panel removed. |

Power Management Module (PMM)

| | |
|---|---|
| Weight: | Approximately 1225 lb (556 kg) |
| Height: | 48.7 in (123.7 cm) |
| Width: | 52.5 in (133.4 cm) |
| Depth: | 31.9 in (81 cm) |

RO Water Treatment System

| | |
|---|---|
| Weight: | Approximately 60 lb (27 kg) |
| Height: | 41.3 in (104.9 cm) |
| Width: | 18.1 in (45.6 cm) |
| Depth: | 17 in (43.2 cm) |

### *3.3. LOCATION*

The system must be mounted on a flat, level surface capable of supporting the weight of the FCSM and the PMM. The FCSM requires ducted venting to the outdoors, so close proximity to an outside wall is preferable.

The PMM must be located within 1 ft (30 cm) of the FCSM, with adequate clearance for the cabling between the units.

### *3.4. MOUNTING*

The PMM and FCSM will be delivered with casters installed. These casters should be replaced with leveling mounts for permanent installations where the system will not be moved. This ensures that the system is not inadvertently shifted or moved after the utility connections (i.e. fuel line, water line, venting, etc.) have been made.

The RO Water Treatment system is supplied with a support for free-standing applications. Alternatively, the mounting panel has holes on 16 inch centers for mounting the RO system to a wall or other vertical surface.

### *3.5. FUEL*

#### 3.5.1. Methanol Specification

| |
|---|
| **PURITY**-wt% |
| 99.85 minimum |
| **APPEARANCE** |
| bright & clear, free of suspended matter |
| **COLOR**-platinum cobalt scale |
| 5 maximum |
| **SPECIFIC GRAVITY** |
| 0.791 – 0.793 |
| **WATER**-wt% |
| 0.10 maximum |
| **ACIDITY**-as acetic acid wt% |
| 0.003 maximum |
| **ALKALINITY**-as ammonia wt% |
| 0.003 maximum |
| **PERMANGANATE TEST**-at 15°C, minutes |
| 60 minimum |
| **ACETONE**-wt% |
| 0.003 maximum |
| **DISTILLATION RANGE**-at 760 mm Hg |
| not more than l°C including 64.6°C |
| **CARBONIZABLE SUBSTANCES**-platinum cobalt scale |
| 30 maximum |
| **WATER MISCIBILITY** |
| No turbidity after 1 hour at 25°C when 1 volume is diluted with 3 volumes of distilled water |
| **NON-VOLATILES**-gram/100 ml |
| 0.001 maximum |
| **Chlorides**-As $Cl^-$ mg/kg |
| 0.5 maximum |
| **Ethanol**-mg/kg |
| 50 maximum |

All other issues pertaining to the methanol fuel used in the fuel cell system, delivery, storage, MSDS, etc. need to be directed to your methanol supplier. IdaTech is working with Methanex to develop a methanol fuel infrastructure. Methanex is aware of and very supportive of the BPA fuel cell development program in the form of competitive pricing and flexible delivery requirements. IdaTech recommends using Methanex as your methanol fuel supplier. The contact information for Methanex is:

| | | | |
|---|---|---|---|
| Business Address: | Methanex Corporation | | |
| | 1800 Waterfront Centre, 200 Burrard Street | | |
| | Vancouver, B.C. V6C3M1, Canada | | |
| Contact | Mark Allard | | |
| Phone: | 604-661-2672 | FAX: | 604-661-2676 |

#### 3.5.2. Physical Connection

(Refer to Fuel Cell System Interconnect Diagram in the Appendix.) The fuel inlet connection consists of a ¼" compression-style fitting on a stainless steel tube located on the back of the FCSM. Stainless or approved plastic tubing (e.g., polyethylene) is used to connect the external fuel storage tank to the system. Physical protection of the external fuel line is recommended. A shutoff valve on the supply line before it enters the system is supplied with the system. A shut-off valve on the supply line located at the fuel storage tank is required.

#### 3.5.3. Fuel Supply

The methanol fuel supply must be located within 30ft (9m) of the installed FCSM. The installed elevation of the bottom of the fuel storage tank must be equal to or greater than that of the system. Transport of the fuel to the system mixing tank is accomplished by a pump provided with the FCSM.

### *3.6. WATER/HEAT RECOVERY SYSTEM*

Connection to a domestic water supply is required. There are two connections from the domestic supply to the system. Make one connection with ½ inch tubing and compression fitting at the back of the FCSM. Make the other connection with ¼" plastic tubing at the RO Water Treatment System using the push-to-connect fitting on the RO system.

At full load, the FCSM will consume approximately 5 gallons of treated water per 24 hour period. This treated water is produced by the RO system and supplied to the FCSM on demand. The operating efficiency (recovery) of the RO system depends on the temperature and quality of the water supply. Assuming a 50% efficiency, the RO system will consume ("waste") 5 gallons of water in the process of producing the 5 gallons of treated water. Thus, the water requirement for the entire system will be approximately 10 gallons per 24 hours, depending on temperature and quality. Water pressure requirements are:

| | |
|---|---|
| Minimum | 40psig |
| Maximum | 60psig |

While most water systems are above the minimum rating, in some cases of high supply pressure, the customer may need to install a static pressure regulator to limit the pressure to no more than 60psig. A shutoff valve on the supply line before it enters the system is also required.

A 10ft piece of ¼" poly tubing with compression fitting is supplied with the fuel cell system. This line will be connected to the water discharge line located on the back panel. The maximum amount of water discharged from the FCSM at full load is 5 gallons per 24 hour period. In addition, depending on water temperature and quality, the RO system will discharge approximately 5 gallons per 24 hours, for a total discharge of 10 gallons per 24 hours. This line should be routed to a floor drain or properly connected to the building drain system. In those cases where connection to a drain system is not possible, a container of appropriate capacity may be placed under the fuel cell system to capture the discharged water and then emptied when full.

Domestic (cold) water inlet and (warm) water outlet fittings are located on the back of the systems. The fittings are ½" compression-style (Hoke Gyrolock) on copper tubing. Warm water discharge from the heat recovery system is routed to an on-site warm water storage tank if the Heat Recovery Option is used.

Please see Option 1, Figure 3, if the heat recovery option is used. Please see Option 2, Figure 4, if heat recovery is not being used.

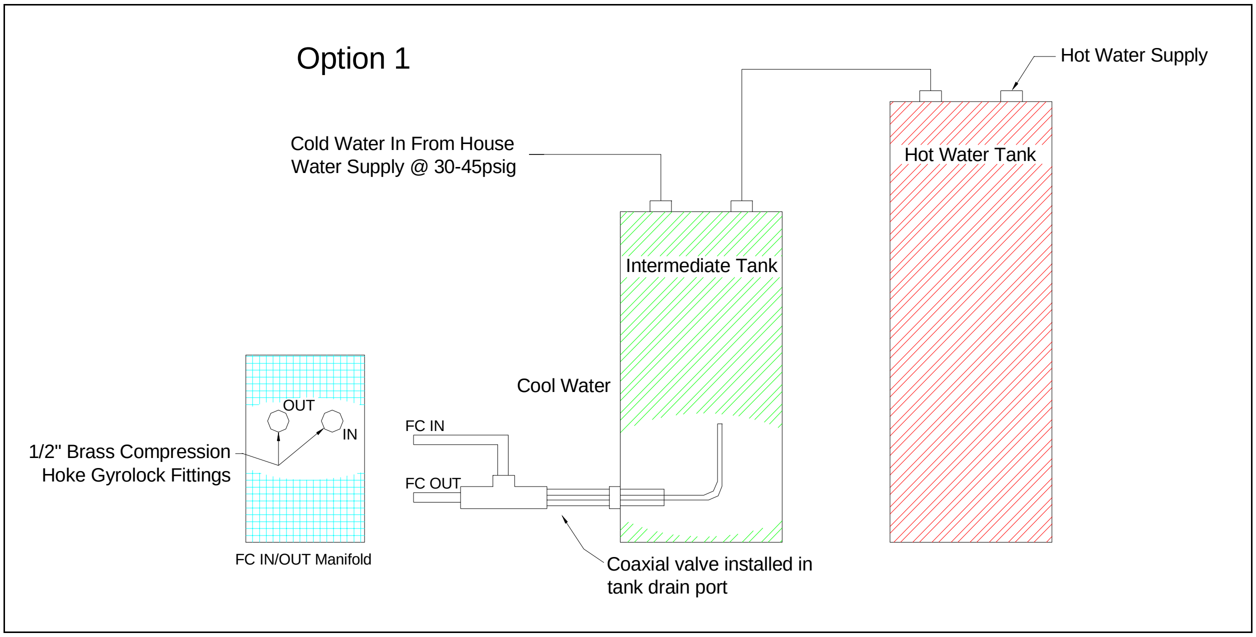



**Figure 3**

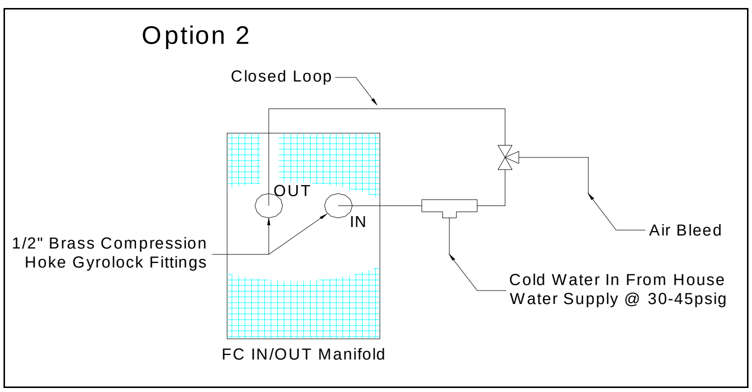


**Figure 4**

### *3.7. EXHAUST GAS DUCTING*

The fuel cell system includes an external inline exhaust fan that is designed to provide adequate air flow as long as the pressure drop of the flue at 105 Cubic Feet per Minute (CFM) does not exceed 0.25 inches of water gauge. Insulated double wall duct, such as Dura-vent, is recommended, and all joints and seams must be sealed or banded to prevent leaks. The downstream side of the inline fan is 5” diameter.

If the static pressure exceeds the above rating, the customer will be required to install additional forced ventilation. If additional ventilation is installed then the duct system cannot exceed a calculated or measured rating of 120CFM @ 0.25 inches of pressure. Please note that the location of any additional draft fan should be within the environmentally controlled building envelope to avoid condensation and freezing issues. Utilization of an existing gas duct with the above requirements would be an option.

Prescriptive Duct Design: Horizontal ducts terminating through exterior walls should not exceed 20 feet in length for 4 inch diameter duct or 15 feet in length for 3 inch duct. 2-90 degree elbows or 4-45 degree elbows are allowed. Vertical duct runs may have up to 30 feet of 4 inch diameter duct or 20 feet of 3 inch diameter duct, with 2-90 degree elbows, 2-45 degree elbows plus 1-90 degree "T" or elbow, or 4-45 degree elbows. Horizontal sections not to exceed 10 feet in length are acceptable for predominately vertical ducts for both 3 and 4 inch duct diameters.

### *3.8. ELECTRICAL CONNECTION*

The 115VAC/60Hz user load is connected to the Power Management Module using SO cable terminated with a 2-pole, 3-wire, 30 amp, 125 volt twist lock connector body (e.g. Hubbell HBL2611). Attachment of the cable to a load bank or breaker panel should comply with local codes and the latest edition of the National Electrical Code. Installation by a qualified, licensed electrician is required.

A single 20 amp 120 volt circuit is required to power the data acquisition system, the exhaust fan, two combustible gas sensors, and the RO Water Treatment System.

### *3.9. CONCLUSION*

In general the requirements of Section 3 for the end-user are:

- Water connection: Run a copper line from the domestic water supply to within 3 feet of the anticipated location of the fuel cell system. At that end-point connect a ball valve with ½” FPT threads and the installation crew will finish the connection to the fuel cell system and the RO Water Treatment System.
- Fuel connection: Install a ¼” stainless steel pipe or tubing from the location of the methanol storage tank to within 3 feet of the anticipated location of the fuel cell system. The final connection between the fuel cell system **and** the fuel tank will be made by the installation crew with steel-braided flexible lines.

- Exhaust connection:  Install the duct work from the terminal fitting at the wall or roof to the vicinity of the fuel cell system.  Once the fuel cell system is in place and prior to operation,  the final connection can be made by the heating contractor.
- Drain line connection:  This connection may be a gravity-fed 1/4 inch poly tube.  The drain line will be installed after the system is installed and it would typically be run open-ended into a floor drain. We can also tap into a PVC drain line and install a compression fitting, but the point of connection must be lower than the FCSM for proper flow.  Do not permit the drain line to become obstructed with ice (i.e., keep from freezing).
- Duplex receptacle:  A 20A/120VAC circuit supplied from the building electrical system should be available near the system location.  An extension cord plugged into a nearby receptacle and routed to within 3 feet of the system location would be adequate.  During installation of the system a small surge strip will be plugged into the 120VAC circuit and used to power the DAQS, combustible gas detectors, RO system, and the system exhaust fan.

# 4. OPERATION

WARNING: This system should be operated by trained personnel only. Before attempting to operate the system, personnel should read this manual thoroughly, and become familiar with the entire system. Fuel Cell Systems are very safe when operated properly, but precautions must be taken to ensure its long life, and the safety of the people working on and using the system.

The Fuel Cell System Module is designed for operation with minimal operator attendance. Once the system is installed and *Startup* is initiated, the system will monitor all critical system parameters and run the system in a safe and efficient manner.

Liquids which may contain methanol should be treated according to the Material Safety Data Sheet (MSDS) located inside the front cover of the Methanex Methanol binder. A copy of the MSDS is also included at the back of this manual.

## *4.1. STARTUP*

1. Check propane pressure, 15 psig. Lift lid on FCS to see gauge on propane tank
2. Check that exhaust fan is on, methanol valves are open, water valves are open
3. Turn the data PC on
4. Close (toggle up) *System AC* breaker
5. Close both the *Battery* and *Fuel Cell*, 250A breakers

At this point on the Trace inverter display screen you should see:

```
Set   Inverter

OFF   SRCH   ON   CHG
```

6. Press the red ON/OFF MENU button on the inverter control panel until the cursor is under ON.
7. On the left side of the inverter is a red toggle switch. Move this to the up position. The inverter is now on and delivering AC power to the user load.
8. Raise lid on the FCS. TURN and HOLD switch to the START position until you hear a beep. Release switch.
9. Check the Data Logger screen on the computer and you should see the Memb Burner Temp increasing.
10. Wait 45 minutes for the FCS to come on line. The LCD screen on the FCS will display the message “Online”

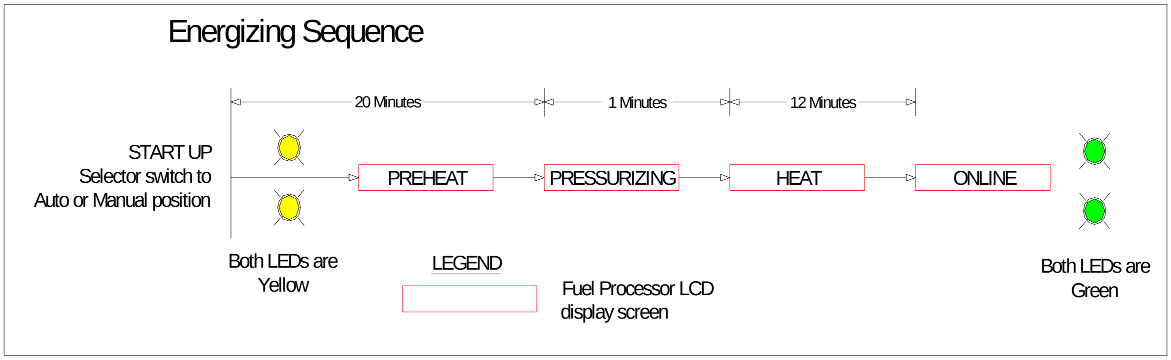



**Figure 5**

### *4.2. NORMAL SHUTDOWN PROCEDURE*

1. Raise lid on FCS. TURN switch to the OFF position
2. Wait until FCS is off, approximately 20 minutes. Both lights on the lid of the FCS will be off and the system will be quiet
3. Open (toggle down) ALL breakers on the PMM
4. Shutdown PC

### *4.3. SHUTDOWN DUE TO A FAULT*

The system will be beeping

1. Lift the lid on the FCS and move the switch to the OFF position. This will silence the beeper
2. Look at the error message on the LCD. See Section 6 TROUBLESHOOTING to determine a course of action.

### *4.4. EMERGENCY STOP*

There is a red Emergency Stop button, readily visible on the PMM. This emergency stop is to be used only in cases of EXTREME EMERGENCY. Operation of this switch may cause damage to the fuel cell system and must be avoided for casual shutdown of the system.

# 5. MAINTENANCE

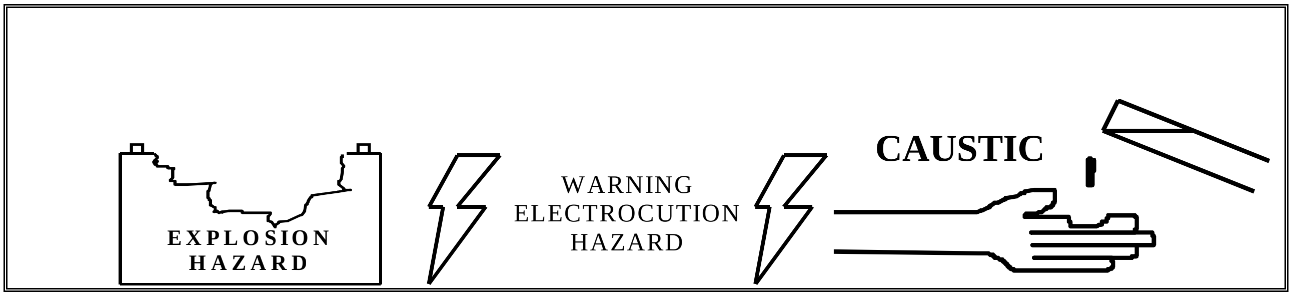
Limited periodic maintenance of the system is required. This maintenance is limited primarily to changing the water filter, DI column, and fuel filter after 1000 hours of operation, filling the propane tank when empty, and ensuring that the PMM battery water levels are adequate.

As runtime is accumulated on systems within IdaTech testing facilities, maintenance issues will become more defined. Maintenance Bulletins will be issued from IdaTech to all Alpha adopters as maintenance procedures change.

## *5.1. PROPANE*

Initial heating of the fuel processor is done by burning a supplemental fuel, propane. Located just inside the lid of the system is a 1 gallon propane fuel tank. This tank will require refilling approximately every 20-30 days. It is a standard tank with standard fittings so it will not require any special consideration when refilled.

## *5.2. BATTERY BANK*




The battery bank is located within the PMM. To access the batteries it is necessary to remove the lid from the PMM. Once this lid is removed the batteries can be accessed for maintenance.

| |
|---|
| CAUTION: Batteries can be extremely dangerous. There is a large amount of energy stored in batteries and shorting the terminals on a battery will cause a destructive release of this energy. |

<u>Cleanliness</u>
It is very important to keep the battery bank clean for safe and efficient operation. A clean battery is free of dirt and electrolyte on the cell surface.

<u>Record Keeping</u>
For service and warranty purposes, it is critical to keep accurate records on the battery bank. A Battery Service sheet is included in the back of this section.

<u>Watering</u>
The batteries contain liquid which is a mixture of water and battery acid. This solution is called the electrolyte. Batteries lose electrolyte through daily usage and it is essential to replenish the loss periodically with distilled water. The electrolyte level needs to be checked every month. Distilled water should be added if the electrolyte level is low. Care should be taken not to overfill the batteries.

# BATTERY SERVICE RECORDING FORM

The batteries should be checked every month. Proper battery handling methods need to be observed when ever checking or servicing the batteries. Adequate gloves and face protection need to be worn when working with batteries.

When checking the batteries a consistent battery numbering system is critical. A suggestion is to go from left to right, back to front, relative to the front of the PMM. Such as:

| | |
|---|---|
| Battery No 1 | Battery No 2 |
| Battery No 3 | Battery No 4 |

| **Date** | **Battery No.** | **Voltage** | **Hydrometer Reading** | **Comments/Technician** |
|---|---|---|---|---|
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## 6. TROUBLESHOOTING

Fuel Cell-Error Messages

| | LCD Message | User Action |
|---|---|---|
| 1 | Water Level Low | Ensure water shutoff valve is open and domestic water is being delivered. **Restart** |
| 2 | Water Flow Low | **Shutdown**. Call IdaTech 541-383-3390 |
| 3 | Water Temp High | Check ambient temperature. Ensure that the radiator is not blocked and the radiator fans are working. **Restart** |
| 6 | Air Pressure Low | **Shutdown**. Call IdaTech |
| 7 | Air Pressure High | **Shutdown**. Call IdaTech |
| 8 | H2 Pressure Low | **Shutdown**. Call IdaTech |
| 9 | H2 Pressure High | **Shutdown**. Call IdaTech |
| 10 | Cell Voltage Low | **Restart**. Do not exceed 2 times |
| 11 | Cell Voltage Timeout | **Restart**. Do not exceed 2 times |
| 13 | Processor Shutdown | See Fuel Processor-Error Messages |
| 14 | Air Temp High | **Shutdown**. Call IdaTech |
| 15 | H2_Temp High | **Shutdown**. Call IdaTech |
| 17 | FPCU Comm Link | Push Emergency Stop. Wait 5 secs and pull out. This action will cycle power to the electronics and cause them to reset. **Restart** |
| 18 | Super Reset | **Restart** |
| 19 | Power Fail Reset | **Restart** |
| 20 | Watch Dog Reset | **Restart** |
| 21 | Manual Reset | **Restart** |

Fuel processor error messages are on the following page.

Fuel Processor-Error Messages

| | LCD Message | User Action |
|---|---|---|
| 1 | Main Burner Light | Check that propane is on and at 15 psig. **Restart 2x** |
| 2 | Main Burner Flameout | **Restart** |
| 3 | Memb Burner Light | Check that propane is on and at 15 psig. **Restart 2x** |
| 4 | Memb Burner Flameout | **Restart** |
| 5 | H2 Pressure High | **Restart** |
| 6 | Feed Pump Overload | **Restart** |
| 7 | Catalyst Overheat | Wait 1 hour**. Restart**. |
| 9 | Out of Fuel | Check fuel supply. **Restart** |
| 10 | Mix Tank Empty | **Shutdown**. Call IdaTech 541-383-3390 |
| 11 | Membrane Overheat | Wait 1 hour. **Restart**. |
| 12 | Reforming Pres. High | **Restart** |
| 13 | Feed Pressure High | **Restart** |
| 14 | Pressurization Fail | **Restart** |
| 15 | H2 Quality Drop | **Restart 1x** |
| 16 | Controller Reset | **Restart** |
| 17 | Heat Timeout | **Restart** |
| 18 | FCCU Comm Error | Push Emergency Stop. Wait 5 secs and pull out. **Restart** |
| 19 | Water Mix Timeout | Ensure water shutoff valve is open and domestic water is being delivered. **Restart** |
| 20 | Exhaust Flow Low | Check exhaust duct connections, look for blockage |

These systems are Alpha prototype, field test units. They will have problems and errors, it is the nature of the Alpha test program. Located in the pocket of this binder is a *FC System Fault Log* sheet. You may use this sheet to log all activities associated with the fuel cell system. IdaTech personnel will also use this sheet to log any changes we make to the system.

# 7. APPENDIX